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IS 9692-8-2 (1988): Guide on maintainability of equipment,
Part 8: Maintenance and maintenance support planning,
Section 2: Maintenance support analysis [LITD 2:
Reliability of Electronic and Electrical Components and
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Indian Standard

GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART 8 MAINTENANCE AND MAINTENANCE SUPPORT PLANNING

Section 2 Maintenance Support Analysis

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*Indian Standard***GUIDE ON MAINTAINABILITY OF EQUIPMENT****PART 8 MAINTENANCE AND MAINTENANCE SUPPORT PLANNING****Section 2 Maintenance Support Analysis****0. FOREWORD**

0.1 This Indian Standard (Part 8/Sec 2) was adopted by the Bureau of Indian Standards on 14 September 1988, after the draft finalized by the Reliability of Electronics and Electrical Components and Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This guide is intended to make recommendations for the standardization of maintainability practices and to stimulate ideas in the maintainability field. Organizations acquiring items will find the guide useful in assisting them in defining maintainability requirements and associated programmes. Item suppliers will benefit from use of the guide, gaining an understanding of the requirements for achieving and verifying maintainability objectives.

0.3 This standard is one of the Indian Standards in the series on 'Guide on maintainability of equipment'. Other standards in this series are:

- Part 1 Introduction to maintainability
- Part 2 Maintainability requirements in specifications and contracts
- Part 3 Maintainability programme

Part 4 Test and diagnostic procedures

Part 5 Maintainability studies during the design phase

Part 6 Maintainability verification

Part 7 Collection, analysis and presentation of data related to maintainability

0.4 This part of the series consists of the following 4 sections :

Section 1 General

Section 2 Maintenance support analysis

Section 3 Maintenance planning analysis

Section 4 Maintenance support resources requirements

0.5 In the preparation of this standard, assistance has been derived from the IEC Doc 56 (Central Office) 132 Draft IEC Pub 706: Guide on maintainability of equipment: Part 8 — Maintenance and maintenance support planning, issued by the International Electrotechnical Commission (IEC).

1. SCOPE

1.1 This standard (Part 8/Sec 2) provides guidance regarding maintenance support analysis (MSA).

2. TERMINOLOGY

2.1 The terms and definitions as given in IS : 1885 (Part 39)-1979* and IS : 7690-1975† shall be applicable for the purpose of this standard.

3. MAINTENANCE SUPPORT ANALYSIS (MSA)

3.0 The specific tasks which are parts of the MSA and which are performed on an iterative basis

throughout the acquisition cycle are described in this standard. The selection of these tasks, and their extent and depth to a particular application will vary with the programme needs and constraints. The tasks can be divided into the following general groups:

- a) Use (mission) and maintenance support system definitions; and
- b) Preparation and evaluation of maintenance support alternatives.

Documentation of MSA shall consist of all data resulting from analysis and tasks conducted and shall provide maintenance support design data. It shall provide means of verification of maintenance support decisions, and provide the basis for acquisition of resources. When the supplier performs MSA, provision of this data to the customer should be specified in the contract.

*Electrotechnical vocabulary: Part 39 Reliability of electronic and electrical items (*first revision*).

†Mathematical guide to the terms and definitions for reliability of electronic equipment and components (or parts) used therein.

3.1 Use and Maintenance Support System Definition — The purpose of the following tasks is to establish maintenance support objectives and maintenance support related design goals.

3.1.1 Use Study — Studies should be made on the use of the proposed system/equipment and should consider the operational pattern, environment, service life, human capabilities and limitations. Pertinent maintenance support factors related to the intended use should be identified and documented. Field visits to operational units and maintenance support activities which most closely represent the planned operational and maintenance support environment should be made. Pertinent maintenance support factors related to intended use of new system/equipment, quantitative data and field visits reports should be documented.

3.1.2 Operational Experience Review Comparative Analysis — Operational experience with similar system should be reviewed to relate past experience to maintenance and maintenance support requirements for the new acquisition. This review shall utilize supply, maintenance and operational information from operating systems. Use should be made of data collection systems and other pertinent documentation backed by the field visits.

This information will be used to make improvements in maintenance and maintenance support. When a comparative reference system can be established, information on the reference systems helps identify the following:

- a) High failure rate potential of subsystems and components;
- b) Major downtime contributors;
- c) Maintenance costs drivers;
- d) Design features which enhance maintenance support;
- e) Potential maintenance support problems — design features which degrade maintenance support;
- f) Design concepts with potential safety or human factors impacts; and
- g) Requirements for maintenance support resources, such as software, personnel, training, technical information, test and support, equipment, facilities and spares.

3.1.3 Maintenance Support System Identification and Standardization — Studies should be made to define maintenance support related design constraints based on existing and planned maintenance support resources. Use of the existing maintenance support resources can substantially reduce life cycle costs, minimize impact of introduction and improve the availability of new system/equipment. Identification of existing maintenance resources can be accomplished by reviewing appropriate documentation and

field visits. Once existing and planned resources have been identified and analyzed and their benefits determined, then maintenance support requirements should be identified and documented in order to provide input into further MSA tanks.

3.1.4 Maintenance and Maintenance Support Related Design Objectives

3.1.4.0 The purpose of this task is to establish the following:

- a) Maintenance support characteristics resulting from various design alternatives and operational concepts. Maintenance support characteristics shall be expressed in terms of feasible maintenance support features, unavailability caused by lack of maintenance support resources, maintenance costs and maintenance resource requirements.
- b) Maintenance support and related design, goals, objectives, and constraints for the new system/equipment for inclusion in system/equipment requirements and specifications as appropriate.

3.1.4.1 These objectives are established on the basis of experience with similar equipment and maintenance support system standardization and are subject to trade-offs to achieve the most cost effective solution. New technological advancements to achieve improvements over the existing maintenance support approaches should be considered and their effects evaluated. Any maintenance support risks associated with the use of new technology should be identified.

3.2 Preparation and Evaluation of Alternatives

3.2.0 The purpose of the following tasks is to establish maintenance support objectives. These tasks are of an iterative nature and are applicable in all phases of the system/equipment acquisition cycle. These tasks are generally performed in sequence; that is, requirements are identified, alternatives are developed to satisfy the requirements and evaluations and trade-offs are conducted. The process is then repeated at lower levels of breakdown and details, and at a time consistent with the design and operational concept development. In the early phases of the life cycle, requirements and alternatives should only be developed to the level required to analyze differences and conduct trade-offs. More detail can be developed after trade-offs are made and the range of alternatives is narrowed. Maintenance support plan must be finalized at a time which allow development and testing of necessary resources to carry it out.

3.2.1 Identification of Maintenance and Maintenance Support Requirements

3.2.1.0 The purpose of this task is to identify maintenance and support functions that must be performed for each system/equipment alternative

under consideration and then to identify the resources that must be available in order to operate and maintain the new system/equipment in its intended environment. This task must be performed early enough to be able to affect design decisions to assure that the resulting system/equipment will achieve the best balance between cost, schedule, performance and maintenance support.

3.2.1.1 Requirements which are unique to the new system/equipment due to new technology or operational concepts, or which are significant from maintenance support, cost and availability point of view should be identified as well as any risks involved in not being able to satisfy these requirements.

3.2.1.2 Preventive maintenance, corrective maintenance, operations and other support tasks should be identified using the following methods:

- a) Failure mode and effects (FMEA) or equivalent shall identify the possible failure modes and their effect on system/equipment operation and document corrective maintenance requirements. These analysis should be performed at the required level of breakdown consistent with the maintenance level considered. The analysis will also provide the basis for built-in and external test specification and evaluation,
- b) Preventive maintenance requirements shall be specified by means of reliability centered maintenance (RCM) analysis which is based on FMEA data, and
- c) Operations and other maintenance support tasks not identified by FME or RCM analysis should be identified through analysis of functional requirements and intended operation of the new system/equipment.

3.2.1.3 The output of the task of identification of functional requirements for maintenance and maintenance support provides input into formulation of design and maintenance support alternatives which satisfy the above requirements in a cost effective way.

3.2.2 Maintenance Support Alternatives

3.2.2.0 The purpose of this task is to establish alternative maintenance support concepts for the new system/equipment alternatives which satisfy the stated requirements. Each alternative maintenance support concepts will be developed to a level of detail commensurate with the hardware and software development.

3.2.2.1 Initial maintenance support alternatives will be system level maintenance support concepts which address support features, costs, critical items and the unique requirements of a new system. After evaluation of these alternatives, alternatives will be formulated at a lower level for further trade-offs and evaluations. This process continues in an iterative

manner throughout the acquisition process until it is transformed into a detailed support concept covering all lines of maintenance and selected items of hardware and software requiring maintenance support and all, or major operation and maintenance tasks.

3.2.3 Evaluation of Alternatives and Trade-off Analysis

3.2.3.0 The purpose of this task is to determine the preferred maintenance support system alternative for each system/equipment design alternative as an input for selection of the best design. Trade-off analysis between design, operational and maintenance support alternatives is an inherent part of system development. Optimum benefits are realized when these analysis are conducted considering all system factors (cost, schedule, performance and maintenance support) before the systems are finalized. The nature of the trade-off models and techniques used, and the magnitude, scope and level of detail of the analysis will depend upon both the acquisition phase and the system complexity. Trade-offs early in the programme will generally be interdisciplinary and broad in scope. As development progresses, trade-offs are progressively refined, inputs become more specific and outputs influence a smaller number of related parameters.

3.2.3.1 The following steps should be followed in evaluation and trade-off analysis:

- a) Identify the criteria related to the maintenance support, cost and availability requirements which will be used;
- b) Select or construct analytical relationships or models between maintenance support design, operational and any other identified evaluation criteria;
- c) Conduct trade-off or evaluation using the established relationships or models and select the best alternative(s) based on established criteria;
- d) Conduct appropriate sensitivity analysis of those variables which have a high degree of risk or have a significant effect on maintenance support, cost or availability for a new system/equipment; and
- e) Document trade-off and evaluation results including any risks and assumptions evolved.

3.2.3.2 Trade-offs between the maintenance support alternatives identified for the new system/equipment are conducted to identify the maintenance support approach which best satisfies the requirements. Alternatives can then be ranked and the sensitivity of the results to change in key design, operating or maintenance support factors can be determined. Results, including the rationale for selection and rejection of alternatives, should be documented for subsequent iterations and refinements. Trade-off analysis results, both between maintenance

support alternatives and between maintenance support, design and operational alternatives become a prime data input into the system design decision process. As such, the trade-off analysis results must include identification of assumptions and risks involved.

The best maintenance support approach is selected as a result of trade-off analysis. The maintenance concept is firmed into the selected maintenance support system which provides the framework for the development of the necessary maintenance support resources and the maintenance plan.

3.3 Determination of Maintenance Support Resource

3.3.0 Using the selected maintenance support system determined from the analysis discussed earlier, specific maintenance support resources should be determined. Maintenance support resource requirements associated with proposed system/equipment alternatives must be identified and refined as the system/equipment progresses through its development. As the design progresses, specific design and operational data will be analyzed to more completely identify detailed maintenance support requirements. Detailed input data for identification of maintenance support requirements are generated by many engineering functions. These activities must, therefore, be closely coordinated to avoid duplication of effort and assure timely availability of required input data.

3.3.1 Maintenance Task Analysis and Maintenance Support Resources Identification and Specification — The purpose of this analysis is to identify required maintenance tasks for the new system/equipment to:

- a) identify detailed maintenance support resource. (Details are described in Section 4 of this Guide);
- b) provide data required for the development of design details to reduce maintenance and maintenance support costs, and to optimize maintenance support resource requirements; and
- c) provide source data for preparation of the required maintenance support documentation (technical manuals, training programmes manpower skill lists, etc).

3.3.1.1 The steps involved are as follows:

- a) Conduct a detailed maintenance task analysis of each maintenance task identified for the new system/equipment. This analysis lists procedural steps required to perform the task and identifies maintenance support resources required to perform each task, in

particular, those which are new or critical. Further guidance is given in Section 3 of this Guide;

- b) Identify training requirements and provide recommendation for the best mode of training;
- c) Analyze the total maintenance support resources requirements for each task and determine which tasks fail to meet established maintenance support or maintenance support related design goals or constraints for the new system/equipment. Identify those tasks which can be optimized or simplified or propose alternative detailed designs to bring the task requirements within acceptable levels;
- d) Prepare technical specifications for support resources required; and
- e) Validate the key information contained in the maintenance plan through performance of maintenance task on prototype equipment. Validation of maintenance support should be coordinated with other system engineering demonstrations and tests to reduce time and effort.

3.3.1.2 The output from this task is documented in the maintenance plan. The scope of this task should be effectively tailored through identification of system hardware and software on which analysis will be performed. This task requires most coordination and interfacing with other engineering disciplines involved in the life cycle of the system/equipment.

3.3.2 Field Analysis — The purpose of this analysis is to assess the impact of introduction of the new system/equipment on existing systems and facilities, identify sources of manpower and personnel to meet the requirements of the new system/equipment, determine the impact of failure to obtain the necessary support resources for the new system/equipment and determine the minimum required resources for specified environment.

3.4 Assessment of Maintenance Support

3.4.1 The purpose of this task is to assess the achievement of specified support requirements and identify methods of correcting deficiencies and enhancing system effectiveness. Maintenance support problems are identified and appropriate corrective action taken contractual compliance with quantitative support and support related design requirements should also be demonstrated. Realistic test environments shall be established considering the intended operational environment and the proposed maintenance support resources. Verification can also be performed by analysis of maintenance, operating and supply reporting systems.

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